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TERMINOLOGY

The term ecological balance refers to the stability of life-forms. When used with reference to the marine environment the term is suggestive of populations balanced precariously between excessive growth and drastic depletion. The affecting factors include chemical constituency, cataclysmic events, storms, over-fishing, pollutants, or even population density itself.[1] When these factors combine to overcome restorative forces, the ecology changes and a new regime comes into balance.

The term semi-enclosed sea is applicable to almost any body of water not completely surrounded by landforms. To narrow the definition, it is necessary to exclude the larger oceans and the smaller estuaries. Oceans connote vastness and unlimited space, while estuaries are the extensions of seas into rivers; neither oceans nor estuaries fall neatly into the category of semi-enclosed seas. Bays, embayments, gulfs, and sounds are also excluded if they are integral parts of an ocean system. Shallow seas can be tentatively excluded as semi-enclosed seas if they may be classed as broad estuaries. Although the spectrum of classification is narrowed by these exclusions, the dividing lines are not precise. It should be noted, moreover, that size has no particular importance. In any event, semi-enclosed seas must connect to some parent ocean or sea and have distinctive interaction with that larger body.

Such distinctive interaction occurs with certain mediterranean seas, marginal or continental seas, as well as with some fjords and straits. The basic feature common to all of these is a high-rise *sill,* or ridge separating the semi-enclosed sea from the parent. Without this sill the sea would be a part of the larger system and its characteristics would be merged with that of the larger body. It can be noted that some ocean basins would fit into the semi-enclosed sea category if land-forms were to rise and enclose them.[2] The several classifications of semi-enclosed seas reflect the various kinds of dominant circulatory processes, which in turn provide the restorative forces for existing ecologies.

Processes

A semi-enclosed sea's process of interaction with a neighboring ocean and with local climatic conditions will induce development of water properties and circulation patterns peculiar to the particular sea, and will set up an ecology suited to these characteristics. As suggested above, ecology has to do with the survival and form of a community of organisms and with their reactions to a number of exterior factors. These factors are related to climate, soil or bottom conditions, water, or other life-forms.[3] Temperature range, for instance, determines what organisms can develop and survive and establishes the regime suitable for symbiosis between organisms.[4] The interrelationship of organisms with affecting factors comprises the ecology.

Where there is little basic change in the relationships of organisms, a balance is maintained and steady state conditions prevail. This is a state of equilibrium, wherein departures from the average fall within a range of conditions for which there is a capacity for restoration to mean values. The natural processes controlling growth and stability will depend upon supply of needed material, catalysis of the environmental situation, and disposal of wasted products.[5] The steady state in a fluctuating environment presupposes an absence of trend and the existence of counter-balancing factors. Consequently, to maintain a steady state, the system requires a flow of material from some inexhaustible source, a conditioning mechanism, and a disposal process to recycle, store, or carry away waste.[6] The period of time applicable to the steady state condition is indefinite, for it depends upon subjective interpretation of appropriate cycle lengths. It is reasonable, however, to assume that semi-enclosed seas are in ecological balance, with a potential for definitive change.

In the very long view, the presence of water on the planet has permitted the evolution of life-forms over a period of a billion years.[7] In the more recent geologic past, the oscillation of the ice ages stored and gave off huge volumes of water so as to shift sea levels dramatically and contribute to climatic redistributions.[8] Because of such factors and because of tectonic crustal movements, the nature of semi-enclosed seas has varied from time to time.[9] Through all of this, however, the remarkable stability of the ocean's reservoir of some billion cubic kilometers of water has acted to modify variations of climate and chemistry sufficiently to maintain continuity of evolution.[10]

Fortunately, seas and oceans are tempering influences, since the heat of tropical regions is stored and carried to high latitudes. The heat sinks of these polar regions transport part of that stored heat into the deeps. The depth to which this heat is transported depends upon the vertical density gradient.[11] Where there is no gradient and where the density is uniform, there is no limit to the depth of convective mixing.[12] However, if the density, in the absence of pressure, increases with depth, vertical transport is inhibited. As a function of temperature and salinity, density of sea water is increased as water is cooled or as salt content becomes more concentrated. Evaporation increases the salinity and uses up some of the heat content, passing that heat off in the form of water vapor. Thus density at the sea surface may be increased by either the process of cooling or the process of evaporation. The instability of surface density, as it increases, permits the water to overturn and to store heat below the surface.[13]

A combination of cooling and salt concentration occurs in the formation of sea ice, which, on solidifying, loses some of its salt in the form of brine. The high density this represents produces bottom water. Subsurface mixing affects the vertical density gradient when exterior stresses upon the sea surface drive surface water downwards. Wind stress and thermohaline distributions[14] provide the current systems which move the water masses. The additional effects of the moon's gravitational pull and the centrifugal forces due to the rotation of the earth combine with the other stresses to form a remarkably complex engine within the water planet.[15] As the outer parts of this engine, semi-enclosed seas may act as "levering arms" of the ocean system.[16]

Distinctive Features

Semi-enclosed or mediterranean seas are not limited by size. They may be as small as the fjords of Norway and Greenland. They may be as large as the Mediterranean Sea itself, the American

Mediterranean (Caribbean and Gulf of Mexico), or the Australasian Mediterranean (Indonesian archipelago). Besides the common feature of having high-rise sills separating them from a larger ocean, there are several distinctive features relating to horizontal density differences at sill depth, sea level deviations, and thermohaline convection.[17] In most cases, there may be flows over the sill in opposition to flow at the surface. If the larger ocean undergoes some small departure from its steady state, such as a slight increase in the heat budget or a small change in chemical condition, then the marginal or semi-enclosed sea, by virtue of its dependence upon the *upper* layers of the parent ocean, should demonstrate a much larger deviation from its normal state.[18]

Because of the sill, incoming circulation from the parent ocean or sea is derived from those layers above sill depth, which layers are necessarily subject to wider fluctuations than the layers below sill depth.[19] In the Eastern Mediterranean Sea, fifty years of comparing the Adriatic with the Aegean Seas has shown that the salinity differences between Split, Yugoslavia and Athens (Piraeus), Greece can be correlated with the quantity of sea ice about Greenland.[20] Although statistics need not reflect causes and although the precise nature of this correlation is unknown, the example serves to show the possibility of the sensitivity of marginal seas to events far removed. The stability of the ocean engine is, on the other hand, illustrated by the lack of development of the fossil fish coelecanth, which is found near the Comores Islands off Africa in the Indian Ocean.[21] This is an area of constant change, with large-scale monsoon fluctuations. Yet in spite of the periodic shifting of current systems caused by the monsoon phenomenon, the fish remains unevolved, thereby suggesting a very long period of absence of trend in the ocean engine.

The development of sea ports and their economies has been dictated in part by the distinctive characteristics of the adjoining seas.[22] The constancy of sea level without appreciable tide in the Mediterranean Sea has probably promoted the establishment of influential cities in pocket-like protected areas with easy ocean access. The best example of these is the port of Venice, which is now threatened by the sea that had protected it for so long.[23] The absence of a storm in the summer months and the severity of winter storms influenced the conduct of life and commerce within Mediterranean civilizations. The relation of storms to the cyclogenesis contributed by the juxtaposition of continental and maritime regimes is attributable to the interactions between sea and air. The kind of ecological balance existing between civilized communities depended upon the environment, which was controlled by the direct and indirect actions of the sea. If the sill at Gibraltar were removed, the heat budget of the Mediterranean Sea could change, tidal fluctuations might inundate coastal towns, and coasts could be eroded or shifted. The ecology of the water itself would be different and the balance of rainfall and riverflow would be affected. One might even speculate that had the nuclear bomb lost off Palomares exploded and opened the sill of Gibraltar, the ecology of the entire Mediterranean area including the Black Sea would have been affected by a changed regime.

Categories of Marginal Seas

Semi-enclosed seas can be categorized according to local phenomena and water properties.[24] Of the four categories of marginal seas, the first and second categories are concerned with thermohaline convection.[25] The third and fourth have to do with inhibition of convection due to density discontinuities.[26] These properties interact with those of the outer ocean and are gated by the sill separation. There are also semi-enclosed seas within semi-enclosed seas so that complexities of interaction are enhanced by chaining. For instance, the entire Mediterranean Sea is a marginal sea dependent upon the North Atlantic Ocean, but within that sea the Eastern Mediterranean is marginal to the Western Mediterranean, which is separated by the sill of the Strait of Sicily. The Adriatic and Aegean Seas are, in turn, marginal to the Eastern Mediterranean. So some seas exist "generations" removed from the "parent" ocean. The immediate parent sea, modified by exchange with the ocean, affects the smaller body; so, presumably, leverage stages are possible as the number of generations increases.[27] Local phenomena, however, will tend to mask any existing leverage.[28]

There are two kinds of thermohaline convective seas.[29] In both, water at the surface is transformed into dense water that sinks. This water, or a mixture containing the dense water, eventually collects in a pool behind the sill. When the quantity of heavy water rises to sill depth it will overflow and be dispersed within the parent body. In the first type of convective sea the surface transformation may be due to excessive cooling, and, assuming there are no important sea level changes associated with the increased density, the excess accumulation will flow across the sill into the deep ocean as heavy bottom water. Examples of this type occur in the South Polar Basin, the Baffin Sea, the Sea of Okhotsk, and the Adriatic Sea.

The second type of convective sea gives a surface transformation to dense water from excessive evaporation, rather than from cooling. In this second type fresh water that is lifted into the atmosphere leaves a dense salty concentration at the surface. The lowered sea level that this loss of water represents promotes a rapid exchange across the sill. The relatively warm but saline water sinks below the surface and passes over the sill into the deep ocean, where it seeks its own intermediate density level. Because of the deficit from evaporation, more water will enter the marginal sea than will leave by way of the sill. Examples of this kind of sea are the European Mediterranean Sea, the Red Sea, and the Persian Gulf.

The third and fourth types of marginal seas lack appreciable thermohaline convection and are characterized by strong density discontinuities which are maintained throughout the seasons.[30] The third type, without particular differentiation at the surface between it and the parent ocean, locks out the deeper dense water from the interior because of the sill barrier. The ocean water of sill-level density fills the basin behind the sill. The uniform nature of this water behind the sill permits constant mixing below the density discontinuity, with some erosion of the discontinuity itself. It is this phenomenon that has led to the discoveries of ridges and sills before their actual soundings. Examples of this type of sea are the American Mediterranean, the Australasian Mediterranean, the Arctic Sea, and possibly the Tyrrhenian Sea.

In the fourth type, the density discontinuity layer may be strengthened in seas where precipitation and run-off exceed evaporation.[31] This promotes an increase in sea level as well as an increased flow to draw off the light fresh-water in the surface layer. Indrafts of heavier water may enter over the sill to replace the loss. Such a sea may be influenced by local winds or barometric pressures tending to accelerate the surface flow. The salt lost in the surface flow is replaced by compensatory drafts of heavier water. This kind of marginal sea can also promote deep stagnation if the sill is shallow enough, i.e., if it penetrates upwards through the density discontinuity. Deep water behind the sill is then backed up with little possibility of renewal as long as the barrier exists blanketed by the discontinuity layer. Oxygen values become depleted, and when the oxygen is gone it is replaced by hydrogen sulfide as organic decomposition becomes incomplete. Examples of the fourth type are some fjords of Norway, the Baltic Sea, and the Black Sea.

Sensitivity to Other Environmental Conditions

Because of the definitional restriction that semi-enclosed seas be separated from a parent ocean by a sill, it may be correctly anticipated that such seas have considerable sensitivity to environmental conditions.[32] The depth of sill, the budget of exchange processes, and the natural distribution of the water properties affect the type of circulation and redistribution of material.[33] This affects the sedimentary deposition, the fauna and the flora, the sea states, the climatology of the particular sea and its environs, and, thereby, the economy and well-being of the populace dependent upon that sea.[34]

The ecological balance with respect to populations can be shifted with the change of environment within the marginal sea.[35] The four types of sea are governed by the external climatology and the state of sea level over the connecting sill. A change in any of these factors will alter the sea's character and, thus, the very basis of its classification. Each of the four types represent different ecological regimes, and the transfer from one type to another will require a new balance. Extreme examples from the past are the evidences of sea levels 100 meters below present levels, the lower levels being ascribed to the storage of water in the form of ice and snow. The worldwide lowering of sea level in this amount would have landlocked some of the present-day semi-enclosed seas (the Baltic, for instance) and would have changed the characteristics of others.[36] There is geologic evidence supporting the view that the Eastern Mediterranean Sea may have been similar to the Black Sea, with incomplete decomposition of organic material below a discontinuity layer.[37] Sapropelitic muds have been found in corings.[38] These are high in organic content and appear to have been laid down during several ice-age intervals. This means that the salty surface-water had been replaced by layers of fresh and brackish water, a considerable contrast to the present. The remarkable contrast in environmental types is demonstrated by present-day calculations for total water renewal. Under present conditions, it would take 2500 years to renew the water of the Black Sea, 80 years for the Mediterranean, and only 20 years for the Red Sea.[39]

The Effects of Man's Activities

The geological past is not of immediate concern here. Smaller scale changes are. It may be asked, for instance, as sea levels rise (as they must do with further melting of the ice cap) and as glaciers recede, what can engineering do to maintain a desirable steady state? With the depths of sills as controlling factors it is conceivable that modification of sill depths to maintain a certain type of environment has some feasability. The Suez Canal was a major engineering act creating a sill; it is only now allowing species migrations to take place between the Atlantic-Mediterranean regime and the Indo-Pacific-Red Sea regime.[40] It has taken a whole century to wash away the Bitter Lakes salt barrier (estimated by De Lessups to be 13 meters thick), which had prevented these migrations.[41]

Modification of the environment can be seen in different ways.[42] Oil on the water can affect the evaporation rate and the violent stirring from breaking waves, which further promotes evaporation.[43] The Arab-Israeli war closed the Suez Canal and, at least for a time, interrupted the discharge of oily waste from ships into the Mediterranean. In 1963 this amounted to about 800,000 tons of sludge per year being discharged into the Eastern Mediterranean Sea.[44] Rainfall, dependent upon this evaporation for its supply of moisture and salt nuclei, may have been affected across the continent of Asia, far-removed from the Mediterranean.[45] The Mediterranean drainage basin, which includes a large percentage of Europe and of Africa, does not provide any surface flow into the Atlantic Ocean or through the Red Sea. The Sea itself has a deficit which draws upon the fresher Atlantic water. Therefore the fresh water contribution of the drainage area must eventually be transported by meteorological processes to the East, together with the deficit flowing through the Strait of Gibraltar. It should be interesting to see if rainfall records have indicated any correlation with the cessation of oily discharges.

To promote an increased fishery, or to counteract depletion from over-fishing, deep rich nutrients might be pumped or allowed to flow into impoverished waters such as those within the Mediterranean Sea. However, as an engineering action, the purpose itself would require careful investigation and its execution would require detailed planning, for the action could easily be defeated if the new water were too cold or too salty.[46] This water would need to reach the euphotic zone, the upper layers, to be effective. The reverse procedure might be useful if, by pumping water from behind a sill into deep water, one could promote increased circulation. It might be applicable to the Adriatic Sea, for, by accelerating the flow of bottom water south to the Ionian Sea, surface water might be induced to flow into the northern reaches of the Adriatic. An acceleration of the northern circulation would help in removing the excessively polluted water associated with the industrial activities in northern Italy.

Engineering proposals to change conditions within marginal seas should give active consideration to the irreversibility of such action and to the possible deleterious side effects. It is clear that the ecological balance will be affected. Moreover, if the change is too great for the restorative forces, there may be adverse consequences for human populations and economies as well. Such an adverse consequence may be as trivial as a restaurant owner's having to adjust his kitchen for the rainy day customer, or as significant as the staggering damages from a storm that destroys human life and property. For instance, the proposal to dam the Bering Strait to warm Arctic Seas could also promote the warming and melting of the ice-cap.[47] The responsibility for implementing such proposals is indeed great, since the possible side effects can be far-reaching. The state of knowledge and understanding of ocean processes and interactions is not commensurate with the ability to engineer major changes in environmental situations. In order to have sufficient information to retain or obtain the necessary ecological balance, the trend in scientific investigation to overspecialization needs to be reoriented to an interbreeding of scientific disciplines.

Footnotes

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1 See "Animals and Environmental Factors," in H. U. Sverdrup, M. W. Johnson, and R. H. Fleming, The Oceans: Their Physics, Chemistry, and General Biology, pp. 823–73 (N.Y.: Prentice Hall, 1946). See also A. F. Spilhaus, "Ecolibrium," Science 175:4023, pp. 711–15 (1972).

2 K. Qyrtki, 1971 Oceanographic Atlas of the International Indian Ocean Expedition, pp. 452–53 (Washington, D.C.: National Science Foundation).

[3] See "Animals and Environmental Factors," *supra* note 1.

[4] *Id.*

[5] See A. F. Spilhaus, *supra* note 1.

[6] *Id.*

[7] P. K. Weyl, "The role of the oceans in climatic change: A theory of the ice age," METEOROLOGICAL MONOGRAPHS 8:30, pp. 37–62 (1968).

[8] *Id.*

[9] For example, recent corings and their analyses have indicated that the Mediterranean Sea has been open to the Indian Ocean in the geologic past. (Conversations with C. D. Hollister). See B. C. Heezen, and C. D. Hollister, THE FACE OF THE DEEP (N.Y.: Oxford Univ. Press, 1971).

[10] See P. K. Weyl, *supra* note 7.

[11] Density of sea water depends upon temperature and dissolved salt content. Density may be increased by lowering the temperature or by increasing salinity. The complex processes governing the distribution of water of different densities result in the establishment of a density gradient in which density increases with depth. The presence of a vertical density gradient inhibits convective motion according to the strength of the gradient. Violent stirring such as that due to wave action and breaking seas tend to mix surface waters to a uniform density but only to some limited depth. Below this depth of frictional influence a sharp density gradient can develop known as the thermocline in which temperature (and thus density) changes rapidly with depth.

[12] See *id.*

[13] See *id.*

[14] An example of wind stress circulation is given in the region of the Trade Wind Belt where the prevailing winds and the North Equatorial Current flow from east to west in the North Atlantic Ocean. A secondary effect of wind stress resulting in a redistribution of water masses comes about where prevailing winds are directed against a coast at an angle promoting a transport of surface water away from the coast according to the rule that *total* transport must move at right angles to the wind. The water that is driven away from the coast is replaced by subsurface water in the phenomenon known as *upwelling.*

Thermohaline (thermal and saline) circulations are based upon the distributions of the water masses according to their cumulative densities in the vertical sense where, if, in the northern hemisphere, the lighter or less dense water lies to the right, the current will be directed away from the observer.

[15] H. U. Sverdrup, *supra* note 1.

[16] Semi-enclosed seas are related to the larger oceans by way of the more rapidly changeable surface structure. As their own circulations are partially dependent upon the transport over the sill, semi-enclosed

seas may be reflective on the whole of those larger changes, if any, that may occur in the upper layers of the outer ocean.

[17] The term "thermohaline convection" refers to vertical motion in the sea dependent upon density differences and upon density instabilities relative to the temperature and salt condition of individual water parcels amid their surroundings.

[18] See *supra* note 16.

[19] Below the thermocline (see *supra* note 10) seasonal influence is practically non-existent in the deep ocean and change is governed by the deep circulation system. It follows that if the sill cuts off deep circulatory connections, seasonal influence or other upper phenomena will be more effective in the semi-enclosed sea.

[20] Zore-Armanda, in a paper presented in Rome, Italy at the 23rd Congress of the International Commission for the Scientific Exploration of the Mediterranean Sea (1970).

[21] J. L. B. Smith, "Live Coelacanths," NATURE 176:4479, p. 473.

[22] With protection from storms and predatory raids and communicable access to the seas as assets of sea port facilities, the geographical position of the sea front is partially determined by the situation with regard to prevailing winds, seas, and currents, as well as anchorages and approaches.

[23] S. Polli, "Analisi periodale delle serie dei livelli marini di Trieste e Venezia," REV. GEOPHYS. PURA E APPL. 10 (1/2):29–40 (1947).
S. Polli, "Propagazione della marea nella Laguna di Venezia," ANNALI DI GEOFIS 5(2):273–292 (1952).
S. Polli, "Variazione del livello marino con la pressione atmosferida nei porti di Trieste e Venezia," GEOFIS E METEOROL, 8(3/4):41–44 (1960).

[24] G. Deitrich, GENERAL OCEANOGRAPHY (N.Y.: J. Wiley, 1963).

[25] See *supra* note 17.

[26] When a vertical density gradient shows a rapid increase of density with depth, that is, a density discontinuity, vertical motion of discrete water parcels is minimized because of insufficient density differences capable of penetrating downwards through the discontinuity barrier.

[27] The "leverage" expression is used in the sense that small scale changes in the upper layers of the deep ocean may undergo some kind of magnification in the marginal sea which utilizes water from the upper layers of the deep ocean. An inner marginal sea might undergo further magnification referring to the same principle. The idea is presented without proof but with reference to a somewhat analogous principle which Redfield used in determining the phase of relationships of tidal co-oscillating systems such as the Bay of Fundy tides.
A. C. Redfield, "The analysis of tidal phenomena in narrow embayments," papers in PHYS. OCEAN. AND METOR., XI:4, p. 36 (1950).

[28] The "leverage" staging is a postulated phenomenon which would

be difficult to observe and identify. As a phenomenon associated with the upper layers of sea water, considerable "noise" would be introduced by local effects whose greatest influence would be within these upper layers.

[29] See *supra* note 17.

[30] Where density differences are mainly controlled by temperature variations, seasonal changes due to winter cooling can wipe out density gradients and promote vertical homogeneity during the winter season. See *supra* note 26.

[31] The lighter water from river drainage and rainfall will stay on the surface thereby providing a sharp discontinuity in the vertical density gradient.

[32] A marginal sea, defined as having one of the four different types of environment, may fall in another category if exterior forces are sufficient to modify the environment.

[33] Cause and effect are interchangeable in that the distribution of material affects the circulation and the circulation governs the distribution. Consequently, exterior exchange processes by modifying and altering distribution will also affect the circulation.

[34] For general oceanographic reference the following books are recommended:

O. Krummel, HANDBUCH DER OZEANOGRAPHIE, Vols. I & II (Stuttgart: 1911).

H. U. Sverdrup, *supra* note 1.

G. Dietrich, *supra* note 24.

[35] See H. U. Sverdrup, *supra* note 1.

[36] The lowering of sea level or subsidence of the land are matters of considerable concern in the scientific community. A few references picked at random follow.

J. Prestwich, "On the evidence of a submergence of Western Europe and of the Mediterranean coasts at the close of the glacial or so called post-glacial period and immediately preceding the Neolithic or Recent Period," PHILOSOPHICAL TRANS., 184, A (18) pp. 903–84 (1893).

F. P. Shephard and H. E. Seuss, "Rate of post-glacial rise of sea level," SCIENCE 123:3207, pp. 1082–83 (1956).

E. Lisitzin, "Der Wasserstand in der Ostsee als Indikator der Strenge des Winters," GEOPHYSICA 5:4, pp. 162–76 (1958).

[37] Sedimentologists have deduced that the high organic content of some Mediterranean sediments were produced during periods of glacial ice melt when intense stratification of the water column was promoted by the presence of fresh water at the surface with subsequent stagnation in the lower levels. For reference, see E. Olausson, "Studies of sediment cores," REPORT OF THE SWEDISH DEEP SEA EXPEDITION, 1947–1948, 8:6 pp. 337–91 (1960).

[38] The term, sapropelitic, comes from *sappros,* referring to decay, and from *pelos,* referring to mud or clay.

[39] Renewal times are quoted from:
H. U. Sverdrup, *supra* note 1.
A. R. Miller, "The Distributions of Temperature, Salinity, and Oxygen," From the WOODS HOLE MEDITERRANEAN SEA ATLAS. Contribution No. 2726 (1972, in preparation).
G. Siedler, "General Circulation of Water Masses in the Red Sea," in HOT BRINES AND RECENT HEAVY METAL DEPOSITS IN THE RED SEA (E. T. Degens and D. A. Ross (eds.)) (New York: Springer-Verlag, 1969).

[40] O. H. Oren, "Oceanographic and biological influence of the Suez Canal, the Nile and the Aswan Dam on the Levant Basin," Contribution No. 90, Series A, of the Sea Fisheries Research Station, Haifa.

[41] G. Wust, "About the decrease of salinity in the Suez Canal from 1869 until 1937," in "Erdkunde" Vol. 5 (Bonn: Ferd. Dummlers Verlag, 1951).

[42] Mass. Inst. of Technology and Royal Swedish Academy of Sciences, Sponsors, "Inadvertent Climate Modification," REPORT OF THE STUDY OF MAN'S IMPACT ON CLIMATE (SMIC) (Cambridge: MIT Press, 1971).

[43] R. L. Grossman, B. R. Bean, & W. E. Marlatt, "Airborne infrared radiometer investigation of water surface temperature with and without an evaporation-retarding monomolecular layer," J. GEOPHYS. RES. 74:10 pp. 2471–76 (1969).
E. C. Monahan, and C. R. Zietlow, "Laboratory comparisons of fresh water and salt-water whitecaps," J. GEOPHYS. RES. 74:28 pp. 6961–66 (1969).

[44] Quoted from discussions at Preparatory Conference on Pollution of Mediterranean Sea held at Ischia, Italy in April, 1971. The industry claimed that the 1963 estimate had been sharply reduced to 100,000 tons per year and that by universal adoption of the "load on top" system this would drop further to 5,000 tons per year.

[45] This statement follows from the assumption of general west-to-east circulation patterns in atmospheric flow. For further reference see: E. R. Biehl, "Climatology of the Mediterranean area," Misc. Reports No. 13, Inst. of Meteorology of University of Chicago (Chicago: Univ. Chi. Press, 1949); and D. B. Carter, "The water balance of the Mediterranean and Black Seas," in CLIMATOLOGY 9:3 pp. 125–74 (Drexel Inst. of Technology, 1956).

[46] In 1966 the writer proposed consideration of this means for supplying nutrients to the Mediterranean during a lecture at a Congress of the International Commission for the Scientific Exploration of the Mediterranean Sea held at Bucarest, Rumania. The salt-fountain hypothesis had been advanced by Stommel et al. (See H. Stommel, A. B. Arons, and D. Blanchard, "An Oceanographical Curiosity: The Perpetual Salt

Fountain," DEEP SEA RESEARCH Vol. 3 pp. 152–53 (1956) and the project seemed feasible. Induced upwelling experiments are now being conducted off the Virgin Islands by the Lamont-Doherty Geological Observatory (See Under Sea Technology, p. 30 (Oct. 1971).

[47] This is one of the many large-scale engineering proposals talked about in the last five years or so. The objective of this proposal is to provide year-round access to Arctic sea ports.